Region 1, New England

U. S. Army Corps of Engineers
New England District

CENAE-R-PT

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Reference Memorandum

Testing and Non Testing Requirements of 40 C.F.R 227.6 and 227.27Federal Navigation Dredging or Non-federal Dredging Projects, for Open Ocean Disposal.

1. REFERENCES:

See attachment for references.

2. SUMMARY:

This memorandum provides comprehensive review and analysis of the dredging test results. This memorandum addresses compliance with the regulatory testing requirements of 40 CFR Sections 227.6 and 227.27. This evaluation confirms that: 1) all tests required under the Ocean Dumping Regulations were conducted; 2) this project meets the ocean disposal requirements at 40 CFR Section 227.6 for trace contaminants and Section 227.27 for Limiting Permissible Concentration (LPC); and, 3) the dredged material is suitable for unrestricted ocean disposal under US Environmental Protection Agency (USEPA) Region 1/Corps of Engineers, N.E. District (NAE) guidance.

4. MPRSA REGULATORY REQUIREMENTS:

The disposal of dredged material in Massachusetts Bay from a Federal project (or pursuant to federal authorization) or from a dredging project by a non-federal applicant is regulated pursuant to Sections 102 and 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA).

The MPRSA prohibits the dumping of materials into the ocean except as authorized by USEPA or, in the case of dredged materials, by the U.S. Army Corps of Engineers (USACE). Section 102 of the Act directs the USEPA to establish and apply requirements for reviewing and evaluating permit applications (33 U.S.C. Section 1412). The USEPA has adopted such requirements for the evaluation of permit applications for the ocean dumping of materials in the Ocean Dumping Regulations. 40 CFR Section 227.6(a) lists constituents that are prohibited from being dumped unless only present as trace contaminants in material otherwise suitable for dumping (hereinafter referred to as "listed constituents"). Section 227.27 addresses compliance with the LPC. See also, Section 227.13(c).

Section 227.6(b) states that the listed constituents are considered to be present as trace contaminants only when they are present in such forms and amounts that the "dumping of the materials will not cause significant undesirable effects, including the possibility of danger associated with their bioaccumulation in marine organisms." The regulations set forth requirements for determining the potential for significant undesirable effects in Section 227.6(c). In order to be found environmentally acceptable for ocean dumping, it must be found that the liquid phase does not contain any of the listed constituents in concentrations that would exceed applicable marine water quality criteria after allowance for initial mixing (Section 227.6(c)(1)). For the suspended particulate phase (Section 227.6(c)(2)) and the solid phase (Section 227.6(c)(3)), bioassay results must not indicate occurrence of significant mortality or significant adverse sublethal effects due to the dumping of wastes containing the listed constituents.

Section 227.27 of the regulations addresses the LPC. For the liquid phase, Section 227.27(a) provides that the LPC is that concentration which does not exceed applicable marine water quality criteria after initial mixing, or when there are no applicable marine water criteria, that concentration of material that, after initial mixing, would not exceed 0.01 of a concentration shown to be acutely toxic to appropriate sensitive marine organisms in a bioassay carried out in accordance with procedures approved by USEPA. For the suspended particulate phase and the solid phase, Section 227.27(b) provides that the LPC is that concentration of material which will not cause unreasonable acute or chronic toxicity or other sublethal adverse effects based on results of bioassays using appropriate sensitive organisms and conducted according to procedures that have been approved by USEPA and USACE, and which will not cause accumulation of toxic materials in the human food chain.

5. GUIDANCE FOR TESTING AND EVALUATION OF DREDGED MATERIAL

The discussion in Section 6, below, describes how the dredged material proposed for disposal from this project (as described in Section 3, above) was evaluated for compliance with the requirements of 40 CFR 227.6 and 227.27. Testing of the material was conducted following procedures approved by USEPA and USACE, and contained in the joint USEPA/USACE national guidance "Evaluation of Dredged Material Proposed for Ocean Dumping - Testing Manual" (February, 1991) (the "Green Book", USEPA/USACE, 1991), and the regional implementation manual developed by the USEPA Region 1 and NED (USEPA/USACE-NED 1989)*.

These test results were analyzed in accordance with the ocean dumping regulations to ensure that the proposed disposal meets the ocean dumping criteria. If the testing results indicate that the ocean dumping criteria are not met (that there is potential for significant undesirable effects), then disposal is prohibited under 40 CFR 227.6 and 227.13. If the analysis of the testing results indicates that the material satisfies the ocean dumping criteria and that no significant undesirable effects are expected from the dumping, then the material is suitable for disposal.

Applying the national (USEPA/USACE 1991) and regional guidance (USEPA/USACE-NED 1989) *to this project, the material would be suitable for disposal if it meets the ocean dumping requirements including:

- acute toxicity requirements (water column and whole sediment);
- bioaccumulation test results are **below** reference values; or if **above** reference values
- bioaccumulation test results are below any applicable FDA Action/Tolerance Levels; and
- bioaccumulation test results above reference for the bioaccumulative chemicals of concern do not indicate a potential for significant undesirable effects using risk evaluation techniques.

6. RESULTS OF EVALUATION OF THE MATERIAL

a. Evaluation of the liquid phase

The liquid phase of the material was evaluated for compliance with Sections 227.6(c)(1) and 227.27(a). There are applicable marine water quality criteria for constituents in the material, including listed constituents, and the applicable marine water quality criteria were not exceeded after initial mixing. In addition, liquid phase bioassays run as part of the suspended particulate phase on three appropriate sensitive marine organisms show that after initial mixing (as determined under 40 CFR 227.29(a)(2)), the liquid phase of the material will not exceed a toxicity threshold of 0.01 of a concentration shown to be acutely toxic to appropriate sensitive marine organisms. Accordingly, it is concluded that the liquid phase of the material is in compliance with 40 CFR 227.6(c)(1) and 227.27(a). The specific test results and technical analysis of the data underlying this conclusion are described and evaluated in the project's Suitability Determination Memorandum.

b. Evaluation of the suspended particulate phase

The suspended particulate phase of the material was evaluated for compliance with Sections 227.6(c)(2) and 227.27(b). Bioassay testing of the suspended particulate phase of the material has been conducted using three appropriate sensitive marine organisms. That information shows that after initial mixing (as determined under 40 CFR 227.29(a)(2)) at the Massachusetts Bay Disposal Site (MBDS) for barge volumes indicated by the Addams modeling (see Suitability determination).

The suspended particulate phase of this material would not exceed a toxicity threshold of 0.01 of a concentration shown to be acutely toxic in the laboratory bioassays. Thus, to ensure that the LPC is met, the maximum volumes to be discharged in a 4-hour period as determined in the Addams model. The specific test results and technical analysis of the data underlying this conclusion are described in the Laboratory reports and in the Suitability Determination. The factor of 0.01 was applied to ensure that there will be no significant adverse sublethal effects. Moreover, because the suspended particulate phase would only exist in the environment for a short time after dumping, the suspended particulate phase would not cause significant undesirable effects, including the possibility of danger associated with bioaccumulation, since these impacts require long exposure durations (see USEPA, 1994a). Accordingly, it is concluded that the suspended phase of the material complies with 40 CFR 227.6(c)(2) and 227.27(b).

c. Evaluation of the solid phase

The solid phase of the material was evaluated for compliance with Sections 227.6(c)(3) and 227.27(b). This evaluation was made using the results of two specific types of evaluations on the solid phase of the material, one focusing on the acute (10-day) toxicity of the material, and the other focusing on the potential for the material to cause significant adverse sublethal effects due to bioaccumulation. Both types of tests used appropriate sensitive benthic marine organisms according to procedures approved by USEPA and the USACE. The remainder of this memorandum addresses the results of those tests and further analyzes compliance with the regulatory requirements of Sections 227.6(c)(3) and 227.27(b) and with EPA Region 1/USACE-NED guidance.

(1) Solid phase toxicity evaluation:

Toxicity tests were conducted on project materials using amphipods, mysid shrimp, worms and clams, representing the characteristics in 40 CFR 227.27(c). These appropriate sensitive benthic marine organisms are good predictors of adverse effects to benthic marine communities (see, USEPA, 1991). The toxicity of the project sediments was within 10% of the reference sediment toxicity for the worm and clam, and well within 20% for amphipods, and was not statistically greater than the reference sediment for any species tested. These results show that the solid phase of the material does not cause significant mortality and meets the solid phase toxicity requirements of Sections 227.6 and 227.27.

(2) Solid phase bioaccumulation evaluation:

USEPA/USACE (1991) describes an approved process of evaluating bioaccumulation potential using comparative analysis of project sediment bioaccumulation to reference sediment bioaccumulation, FDA Action Levels and evaluation of eight additional factors for assessing the significance of bioaccumulation. These factors are:

- number of species in which bioaccumulation from the dredged material is statistically greater than bioaccumulation from the reference material;

- number of contaminants for which bioaccumulation from the dredged material is statistically greater than bioaccumulation from the reference material;

- magnitude by which bioaccumulation from the dredged material exceeds bioaccumulation from the reference material;

- toxicological importance of the contaminants whose bioaccumulation from the dredged material exceeds that from the reference material;

- phylogenetic diversity of the species in which bioaccumulation from the dredged material statistically exceeds that from the reference material;

- propensity for the contaminants with statistically significant bioaccumulation to biomagnify within aquatic food webs;

- magnitude of toxicity and number and phylogenetic diversity of species exhibiting greater mortality in the dredged material than in the reference material; and

- magnitude by which contaminants whose bioaccumulation from the dredged material exceeds that from the reference material also exceed the concentrations found in comparable species living in the vicinity of the proposed disposal sites.

In following the national and regional guidance, USEPA Region 1 and NAE used a framework (described in Figure 1) for evaluating project sediment bioaccumulation results. As shown in Figure 1, this process involves four consecutive evaluations. In the first three evaluations, the project sediment bioaccumulation test results for each compound of concern are sequentially compared to: a) reference test results; b) FDA Action/Tolerance Levels and c) general and project-specific risk-based evaluations. If these evaluations show that the project sediment does not exceed the reference test results in step (a) for a particular compound, this indicates that the disposal of the material would not result in adverse effects due to that chemical, and there is no need to further evaluate that individual chemical in the next step. The footnoted values in Table 1 indicate where project test results were statistically greater than the MBDS reference levels for the clam or the worm. If these evaluations show that the project sediment results exceed any FDA Action/Tolerance Levels, the material is determined in step (b) not to meet the ocean dumping requirements. General risk based evaluations are conducted in step (c) for compounds not resolved in steps (a) or (b). Carcinogenic compounds are summed to assess total risk in step (c). The fourth evaluation (d) uses all the information and results of the evaluations (particularly as these results relate to the eight Green Book factors listed above), to evaluate the solid phase of the dredged material as a whole. These evaluations for this project are discussed below in the order described in Figure 1.

The contaminants of concern are determined by a federal/state interagency regulatory work group. The specific chemicals that are determined to be contaminants of concern for this project by the New England Federal/State regulatory agencies are found in the suitability detrmination.

Bioaccumulation tests were conducted on the solid phase of the project material for the contaminants of concern using two appropriate sensitive benthic marine organisms, *Nereis virens* and *Macoma nasuta*, which are representative of the three characteristics in 40 CFR 227(c). These species are considered to be good representatives of the phylogenetically diverse base of the marine food chain. The bioaccumulation test results were used in evaluating the potential sublethal impacts of the material. The determination is that the combined results of the toxicity and bioaccumulation tests indicated that the material met the requirements of Sections 227.6(c)(3) and 227.27(b) for ocean disposal, and that the material is suitable for disposal.

(a) Comparison of Bioaccumulation Test Results to Reference Sediment Test Results

Concentrations of contaminants in tissues of organisms exposed for 28 days to project sediments were compared to concentrations in tissues of organisms exposed for 28 days to reference sediment. Reference sediment serves as a point of comparison to identify potential effects of contaminants in the dredged material (USEPA/USACE, 1991). In essence, exposing test organisms to this sediment allows for the prediction of contaminant levels that would result in the test organisms were they "in the wild" at the area from which the reference sediment was taken. The tissue concentrations in two species of appropriate sensitive benthic marine organisms resulting from 28-day exposure to project sediments is compared to the tissue concentrations in the same species of organisms resulting from 28-day exposure to reference sediment. In order to make a statistically valid determination that the project sediment does/does not cause greater bioaccumulation than the reference sediment, several sub-samples of the dredged material and reference are run; these separate sub-samples are called replicates. A mean can then be calculated with a standard deviation for each sediment ,. The means and standard deviations are compared using a standard statistical approach, and a determination is made, with 95 percent confidence, that there is or is not a true difference between the test and reference sediments. A statistical analysis is merely a quantification of the variability between the test and reference data, and a measure of the probability that a true difference exists between the test and reference data. For the remainder of this memorandum, statements regarding project sediment having greater or less bioaccumulation than the reference sediment are referring to statistically calculated differences at the 95% confidence level.

The bioaccumulation data for this project adequately addresses sediment to be dredged from the project location. The sampling plan for the bioaccumulation testing, compositing and sample locations are explained in the Suitability Determination Memo. (The mean values used in the statistical comparisons with reference described above are listed in Table1

The reference sediments used in the bioaccumulation testing for this project were collected at the MBDS Reference Sites, in areas of clean, sandy mud sediments located in Massachusetts Bay near the disposal site, where the sediments are unaffected by prior dredged material disposal (see reference values in Tables 1 and 2 (USEPA/USACE 1991). When bioaccumulation in organisms exposed to project sediments is not greater than bioaccumulation in organisms exposed to appropriate reference sediments, this means that dumping of the material would not result in bioaccumulation above that found to occur in the "clean" reference sediment. Accordingly, such material would not result in bioaccumulation that would cause unreasonable degradation of the environment or human health, or significant adverse effects. In cases where bioaccumulation levels are greater than in the reference, further evaluation for potential effects is warranted. A statistically significant difference between test and reference bioaccumulation is not itself a quantitative prediction that an impact would occur in the field, nor is it related to any cause and effect. A key to understanding bioaccumulation and potential adverse impacts is that bioaccumulation is a phenomenon and an indicator of exposure and does not necessarily result in a significant adverse effect. Depending upon the exposure concentration, exposure duration and toxicity of the material, bioaccumulation may cause no harm. On the other hand, as exposure and subsequent bioaccumulation increases, the potential for adverse effects increases.

(b) Comparison to FDA Action/Tolerance Levels

This evaluation compares the bioaccumulation values in the project to applicable U.S. Food and Drug Administration's (FDA) Action and Tolerance Levels for the compounds measured above reference (Table 3). If there does not exist any FDA Action /tolerance levels for the contaminants of concern, the analysis goes directly to the next step, (c) Risk-based evaluations.

(c) Risk-based Evaluations

The potential for impacts due to compounds that produced greater bioaccumulation from project sediments than the reference sediments was determined using risk-based evaluations.

The highest replicate value for a given measured analyte was used in the FDA shellfish "levels of concern" and risk-based evaluations described below in sections (1), (3), (4) and (6). Table 2 summarizes the highest replicate values for the statistically accumulated bioaccumulation data for the project and the MBDS reference site. When practical quantification was not possible, the highest "J" value (i.e., detected but below the sample-specific detection level) was reported in the table or added in the sum.

For these compounds, the toxicological significance of bioaccumulation from the sediment into benthic organisms was evaluated by: *i) consideration of steady-state bioaccumulation and food-chain transfer; ii) consideration of potential carcinogenic effects on human health; iii) consideration of potential non-carcinogenic effects on human health; iv) comparison with published FDA "levels of concern for shellfish" (USFDA 1993a,b); and v) consideration of potential ecological effects.*

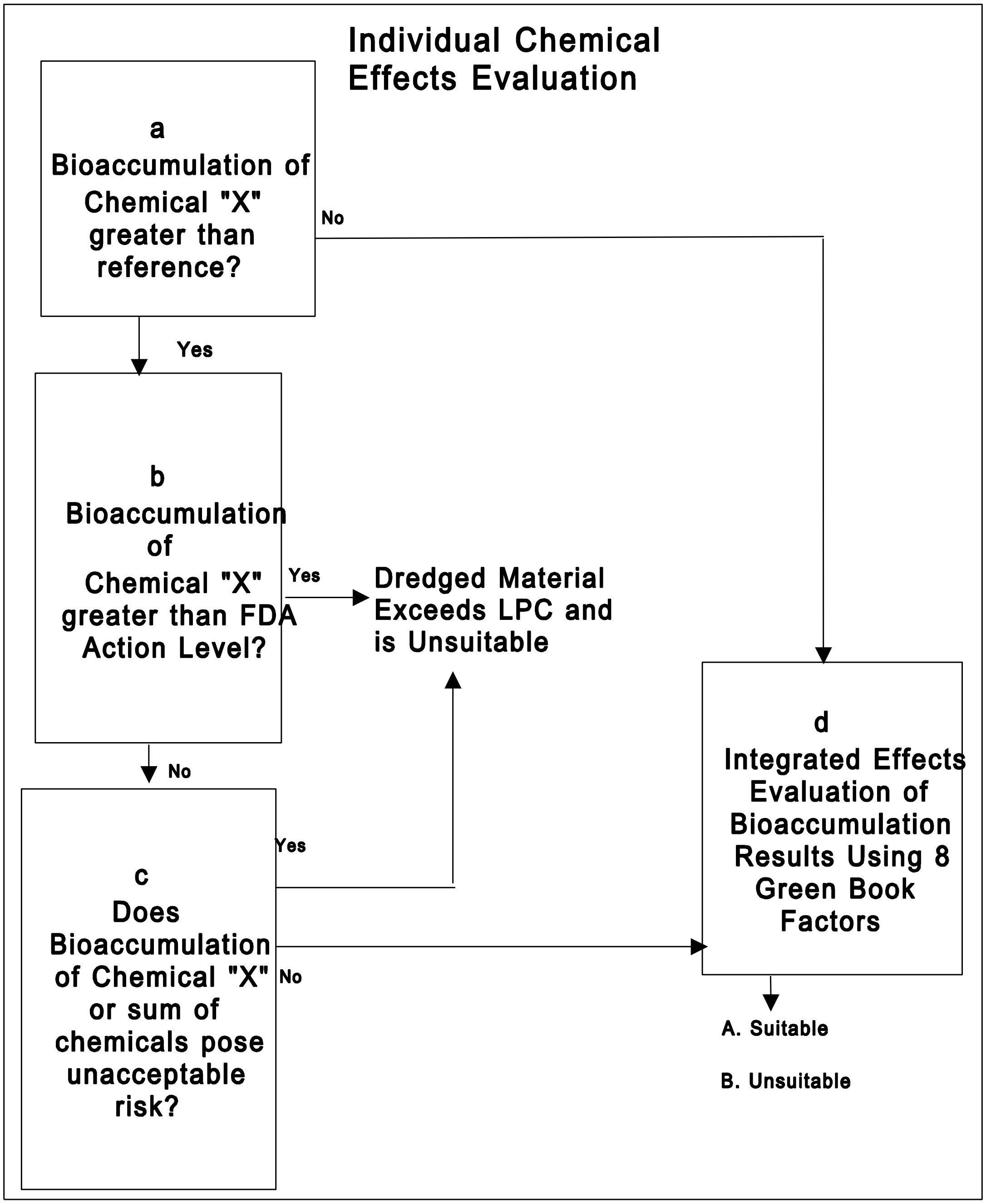
As a conservative measure, the assessment below utilized the highest replicate concentration (Tables 2 and 3) or each human health related risk assessment. The use of the highest replicate is consistent with Region I Risk Assessment guidelines (EPA 1995; Burke, personal comm.). This guidance recommends the use of the 95% upper confidence level (UCL) values for risk assessments which normally have at least 10 replicate samples for the calculation. However, when the sample number is below 10, as in this case (n = 5), the guidance recommends that the highest replicate be used as a surrogate for the 95% UCL as described above (Burke, personal comm.). The mean of the 5 replicates was used in sections *ii* (FDA Action Level) and *v* (ecological evaluation).

(1) *Consideration of Steady-State Bioaccumulation and Food-Chain Transfer*

Since highly lipophilic (high octanol/water partitioning coefficient or K_{ow}) contaminants generally are accumulated at relatively slow (weeks to months) rates, i.e., often longer than the 28-day test, it became necessary to adjust the 28-day concentrations to steady state values assuming the benthic organisms would likely achieve a thermodynamic equilibrium with persistent sediment contaminants at the disposal site over time.

Bioaccumulation tests were conducted using a 28-day exposure of appropriate sensitive benthic marine organisms to the project and reference sediments. As previously discussed, for bioaccumulation evaluations involving comparisons with "steady-state" tissue concentrations (as opposed to evaluations using other 28-day tissue concentrations such as the comparison to reference sediment), it may be necessary to understand the extent to which the organism tissue concentration has reached steady-state. Steady-state may be defined operationally as the lack of any significant difference (ANOVA, alpha = 0.05) among tissue residues taken at three consecutive sampling intervals (Lee, *et al.*, 1989). The 28-day test exposure period was selected as appropriate because most chemicals of concern will reach at least 80% of steady-state in benthic marine organisms within that time frame (Boese and Lee, 1992). For the few chemicals that may not meet steady-state tissue concentrations in 28 days, a factor may be used to adjust the data to steady-state when necessary. In order to better use the tissue concentration results of 28-day bioaccumulation exposure tests to assess the risks posed to the environment from the chemicals requiring further evaluation (see discussion above for the identification of such chemicals), consideration was given to the steady-state concentration of these compounds that could occur in the disposal site after extended periods of time. In addition, the potential movement of these compounds through the food chain was considered and appropriate trophic transfer factors applied to adjust the data accordingly, as described below.

Figure 1. EPA Region 1/NAE Framework for Evaluating Bioaccumulation Test Results



Non-Polar Organic Chemicals

Uptake of non-polar organic contaminants from food is highly dependent on its hydrophobicity, a property measured by the octanol/water partition coefficient, K_{ow}. The higher the value of K_{ow}, the longer it takes non polar organics to reach steady-state in benthic marine organisms. For the organochlorine compounds DDT, chlordane, and some PAHs that have log $K_{ow} > 6$, it is possible that steady-state was not reached within 28 days. As discussed above, the steady state values were estimated using the kinetic models compiled by McFarland (1994, 1995). This series of formulas estimated the time required to reach steady state bioaccumulation based on the log K_{ow}. Then, the steady state value was estimated from determining the fraction of steady state that the 28-day concentration represented. The computations were simplified and incorporated into a curve in the Inland Testing Manual (Figure 6.1 in USEPA/USACE 1998). The inverse of the proportion of steady state concentration at 28 day (y axis) became the Steady State Correction Factor (Appendix I).

The potential for these chemicals to biomagnify was also evaluated. Although organic contaminants with values of log $K_{ow} > 4$ tend to biomagnify in the marine food chain, studies (USACE, 1995) have shown that this is not true for higher molecular weight compounds such as the most highly chlorinated PCBs or for easily metabolized compounds such as PAHs. Those organic compounds which are not efficiently excreted, such as certain pesticides (e.g., DDT), can biomagnify in the food chain. One trophic level above the benthic invertebrate was chosen for evaluation. Winter flounder (*Pseudopleuronectes americanus*) and American lobster (*Homarus americanus*) are common predators at the MBDS and commonly feed on benthic invertebrates at the site. For the organic constituents with a potential to biomagnify in the marine food chain, trophic transfer factors were calculated, using the approach described by Gobas (1993) as computed by Burkhard (1995). The values are summarized in Appendix I.

Metals

In general, metals bioaccumulate more rapidly than organics and 28-day tests are sufficient to evaluate potential effects (see USEPA/USACE, 1991) (Naqvi, *et al.*, 1990; Riedel, *et al.*, 1987; Oladimeji, *et al.*, 1984). Trophic transfer of most metals is not sufficient to qualify as biomagnification (Brown and Neff, 1993). The lack of observed biomagnification for such metals as chromium, copper, lead, nickel, silver, and zinc is the result of incomplete absorption of metals across the gut, rapid excretion, and dilution in muscle, which represents a large part of the total body weight of most marine animals (Fowler, 1982; Suedel *et al.*, 1994). For purposes of conducting the human health and ecological evaluations below, a conservative trophic transfer coefficient equal to one will be used for these non-biomagnifying metals (Suedel *et al.*, 1994 and references cited therein).

(2) *Consideration of Potential Carcinogenic Effects on Human Health*

The carcinogenic risk of the observed bioaccumulation was evaluated using a standard risk screening approach. The general approach used is as follows:

a) The contaminants of concern which were bioaccumulated greater than reference are listed in Table 1. One PAH (benzo(a) pyrene) were identified as Class B2 probable human carcinogens (USEPA 1998). The analysis was based on the highest replicate values listed in Table 2 for these compounds, as described above. Toxic equivalent factors (TEFs) for PAHs (USEPA 1993) were used to calculate benzo(a) pyrene toxic equivalents (Appendix I, Table I-2) for all carcinogenic PAH compounds.

b) Each compound listed above was corrected for steady state and biomagnification as described above.

c) Fish (flounder), lobster and bivalve shellfish were chosen as target species as they are commonly harvested and consumed in Massachusetts Bay.. All these species have a high potential for exposure to the contaminants associated with the MBDS sediments . Although flounder and lobster are mobile predators, they have a high exposure potential because they are benthic feeders and commonly occur at the MBDS. It was assumed that the flounder and lobster would feed exclusively on the clam or worm which was in equilibrium with the dump site sediment contaminants. Since shellfish and worms accumulate contaminants directly from the sediments, biomagnification factors were not applied for the molluscan shellfish. Thus, the steady state corrected clam and worm data were used as a surrogate for an edible bivalve shellfish. The values are listed for each species and samples included in the suitability determination..

d) Lipid normalization of the prey and predator species allowed estimation of human edible tissue concentration in lobster muscle and hepatopancreas and flounder fillet. The dosage to humans was then estimated using standard EPA risk formulas (USEPA 1989b) and conservative consumption rates. Carcinogenic risk for each of the organic contaminants of concern for which EPA-approved human health risk endpoints were available (USEPA 1998), were estimated in Tables 4-6, Appendices II and III for clam and worm prey species

Cancer slope factors were available from the EPA IRIS database for benzo (a) pyrene were used in standard EPA risk models to calculate risk to consumers (USEPA 1989, 1995a).

The results of the carcinogenic risk screen are exhibited in the suitability determination. The acceptible cancer risk should be 10^{-4} or less. Generally, each project is evaluated by estimating the carcinogenic risk value in comparison to reference site values. Each table indicates the risk sums for each consumed species. This analysis confirmed that, although the estimated risks were above reference, the carcinogenic risk of consuming contaminated seafood was lower than the acceptable 10^{-4} , USEPA 1989).

Since the analysis used conservative methods, the results represent conservative estimates of risk, or what are in effect plausible upper-bound estimates. Thus, the true risk is likely to be much lower than the estimated values.

(3) *Consideration of Potential Non-carcinogenic Effects on Human Health*

Non-carcinogenic risk was also evaluated on contaminants which were greater than reference. Reference doses (RfD) for the following were available from the IRIS data base: acenaphthene, anthracene, fluoranthene, fluorene, pyrene (USEPA 1998). An RfD for copper was available from USEPA(1997).

The edible tissue doses (lifetime average daily dose = LADD) for each of these compounds were estimated as described for the carcinogenic risk. The final dosage was estimated and divided by available reference doses. The potential for non-cancer impacts can be expressed as a hazard quotient (HQ), which is the ratio of the average daily intake divided by the toxicological reference dose for the chemical. If the HQ is less than unity (i.e., 1), an adverse noncarcinogenic effect is highly unlikely to occur. If the HQ exceeds unity, an adverse health impact may occur. The higher the HQ, the more likely that an adverse noncarcinogenic effect would occur as a result of exposure to the contaminant in the dredged material after disposal.

The HQs for all the above-listed contaminants are shown in Tables 6 and 7. Based on the available EPA approved reference doses (RfD) for these contaminants, non-carcinogenic risks (hazard ratio) were below unity and therefore inconsequential for human health (Tables 6 and 7)

(4) *Comparison with Published FDA "Levels of Concern" for Shellfish*

Additional human health criteria were available from the US FDA for metals which accumulated greater than reference. For the purposes of establishing seafood safety guidelines for heavy metals, the FDA has published risk-based "levels of concern" for a number of metals including lead (USFDA 1993a, b). Table 8 exhibits the clam and worm body burdens where there was bioaccumulation greater than reference of these metals. In all cases, the metal levels were below the published guidelines for the 95% level of consumption, further indicating that the project would not cause significant undesirable effects.

(5) *Consideration of Potential Ecological Effects*

A review of scientific information was also done to further evaluate the test results with respect to potential ecological impacts for the chemicals that bioaccumulated greater than reference.

Metals, Pesticides, and Industrial Chemicals:

The potential for ecological effects from the bioaccumulation of copper and lead was evaluated by comparing to a calculated Water Quality Criterion Tissue Level (WQCTL) (see Appendix IV for details). The WQCTL is calculated by multiplying the Clean Water Act Section 304(a)(1) Federal water quality criterion chronic value (CV) for the chemical by the empirically determined bioconcentration factor (BCF) for the chemical for a representative marine organism (Lee, *et al.*, 1989). A BCF is the ratio of the concentration of a contaminant in an organism to the concentration of the contaminant in water. Thus, the WQCTL represents the tissue concentration that would be expected in an organism exposed to water containing the chemical at the CV concentration. This level is set to protect 95% of all tested organisms included in the water quality criterion database, thus representing a conservative level of protection (USEPA, 1985b). Sources of CVs and BCFs are USEPA ambient water quality criteria documents (USEPA 1980b, 1980c, 1980d, 1980f, 1984a and 1984b). For all samples, none of the WQCTLs were exceeded in the bioaccumulation test results. Therefore, these bioaccumulation test results do not indicate a potential for significant undesirable effects..

PAHs:
For PAHs, a more definitive method is available for evaluating the potential ecological effects. This method makes use of a direct comparison of total PAH tissue residues and the Critical Body Residue (CBR). This approach is supported by a review of the scientific literature. The CBR approach described by McCarty (1991) was used to evaluate the potential impacts of total PAHs accumulated in the dredged material bioaccumulation test organisms. CBRs are concentrations of chemical residues in organisms which elicit a deleterious biological response associated with narcosis, which is the primary non-cancer effect of PAHs. Narcotic responses measured can be acute (e.g., immobilization or death) or chronic endpoints (e.g., reduced reproduction, fecundity or growth). CBRs are represented as the ratio of the mass of toxicant to the mass of the organism, such as millimoles or micrograms of toxicant per kilogram (mmole or ug/kg) of organism. For the narcosis endpoint, each molecule of individual PAH congeners is generally equipotent; thus, the total PAH concentration is compared to the CBR. For example, a 400 ppb dose of naphthalene would elicit a similar toxicity response to that of 400 ppb of fluorene; if both chemicals are present together at these concentrations, then the dose would equal 800 ppb (see Appendix IV).

Total PAH levels in tissues from the dredged material bioaccumulation tests were well below levels at which chronic adverse effects might be expected from a narcotic mode of action in sensitive aquatic organisms (e.g., fish) as estimated by the CBR.

In addition, Widdows et al. (1987) found that PAHs body burdens of 10 ppm wet weight, were correlated with impacts to reproduction and recruitment in mussels . All steady state corrected total PAH values were below this value.

Effects of Mutagenic, Carcinogenic and Teratogenic PAHs:
Applying the uncertainty factor (UF) of 10 and a trophic transfer factor of 0.1 described in the Appendix IV, to the no-effects level for BaP calculated from Hannah, *et al.* (1982) (8,021 ppb) results in a no-effects level for BaP of approximately 8,000 ppb in benthic tissue, which is considerably greater than the highest mean tissue concentration of BaP found in the project bioaccumulation test results (approx. 38 ppb). Even when applying the more conservative steady-state factors for BaP derived from McFarland (1995), as identified above, the calculated concentrations (77 ppb for BaP) are still well below the no-effects level; the project tissue concentrations would still be well below this no-effects level if the higher trophic transfer factor (0.23) reported by McElroy, *et al*. (1991) was used. Therefore, the most relevant aquatic effects information reviewed indicates that the highest tissue levels accumulated in the dredged material bioaccumulation tests are well below the no-effects level.

Another study that was reviewed considered the carcinogenicity of BaP in rainbow trout resulting from embryo microinjection (Black, *et al*., 1988). A statistically significant number of liver neoplasms was found at a concentration of approximately 200,000 ppb, with non-significant effects at up to one half that concentration. Therefore, using the above across-species UF of 10 and trophic transfer factor of 0.1 results in an aquatic no-effects level of 100,000 ppb. Since this is several orders of magnitude above the highest tissue concentration of BaP for this project, as described above (and even the highest BaP-equivalent levels for human health, as discussed above), this provides additional support for a finding that the test results do not indicate a potential for significant undesirable effects due to mutagenic, carcinogenic or teratogenic contaminants.

Hall and Oris (1991) reported on experiments that exposed fathead minnows to anthracene during long-term exposures and observed adverse effects on reproduction. The paper reported that a concentration of anthracene in the tissue of the egg in the range of 3,750 to 8,000 ppb resulted in no significant effects on egg hatching or survivorship. Using the same approach for accounting for species-to-species uncertainty and food chain transfer described above and in Appendix IV yields a conservative benthic tissue level of 3,750 ppb. Anthracene tissue concentrations from the project bioaccumulation tests are well below this level.

The clam and worm bioaccumulation levels were compared with environmentally conservative ecological effects data to evaluate the steady state corrected tissue contaminant levels. As with the human health risk screen, the highest replicate of each species was used in the analysis. Each value was corrected for steady state as discussed above.

It should be noted that the clam test data represent the maximum contaminant concentrations that benthic invertebrates would have accumulated from the dredged sediments because the species used is an infaunal deposit-feeder with minimal ability to metabolize these compounds. However, because polychaete worms can metabolize PAHs, the assessment of these compounds in this taxon is less conservative.

The concentrations of each steady state-corrected contaminant accumulated in the clam and worm test species were found to be below potential effects levels.

(6) *Risk-based Conclusions:*

Human Health:
The carcinogenic risks for each species consumed (Tables 4 and 5) indicate acceptable levels of risk for a human consumer who eats 1-2 meals per week. The risk sums that were estimated for this project (10^{-4} - 10^{-7}) although above reference are within the acceptable risk range (10^{-4} - 10^{-6}, USEPA 1989b). In addition, this risk screen was environmentally conservative, i.e., protective to human consumers. For example, our assumptions that a fisher consumes his/her catch from the dump site every week of the year and the catch exclusively feed on the contaminated food source (invertebrate prey) overestimate true risk. Other conservative assumptions are outlined in Section II B of this report. Therefore, particularly given the conservative nature of this screen, these test results indicate that the dredged material does not have the potential for significant undesirable effects. The results for this project indicate that non-carcinogenic risk also proved to be inconsequential for the human consumer with all hazard ratios well below one.

Ecological:
All the steady state adjusted tissue residue levels in the worm and clam were below impact levels cited in the literature . Therefore, these bioaccumulation test results indicate that the dredged material does not have the potential for significant undesirable effects.

(d) Evaluation of Solid Phase Bioaccumulation Results for Dredged Material as a Whole

The evaluation of the testing results performed above indicates that the material does not have a potential to cause significant undesirable effects to aquatic marine biota due to chronic adverse effects (lethal and sublethal) including such effects due to mutagenic, carcinogenic, or teratogenic contaminants, or to human health due to cancer or non-cancer effects from the individual contaminants. That evaluation includes the information relevant to the eight factors identified in the Green Book for assessing bioaccumulation test results (USEPA/USACE, 1991). As a final and additional step in the evaluative process, however, it is appropriate to go beyond assessing the individual test results in order to look at the results as a whole so as to provide an opportunity for an integrated assessment of the individual test results (Figure 1, Box d).

As indicated above, the chemicals of concern that were bioaccumulated in the clam and worm test species above reference are indicated in the suitability determination. Although some of the contaminants that were bioaccumulated in the tests can be toxicologically important, in no case did they accumulate to toxicologically important concentrations, even when conservative assumptions were used to evaluate the test results, as described above. PAHs were all below the acceptable human health risk range (10^{-4} or less for carcinogens and a hazard ratio of 1 for noncarcinogens) and within acceptable aquatic effects ranges using such conservative approaches and analyses. In addition, the dredged material as a whole did not cause statistically greater mortality than the reference sediment. Thus, an evaluation of the solid phase bioaccumulation test results for the dredged material as a whole considering the factors in the Green Book (Figure 1, Box d) would not indicate a different outcome from that shown by the individual test results themselves; i.e., that the material does not have the potential for significant undesirable effects due to bioaccumulation.

Taking into account all of the above information, it is determined that there is no potential for significant undesirable effects due to bioaccumulation as a result of the presence of individual chemicals or of the solid phase of the dredged material as a whole. Therefore, it is concluded that the solid phase of the material proposed for disposal meets the ocean disposal requirements at 40 CFR §227.6(c)(3) and 227.27(b), and is classified as suitable for disposal under USEPA Region 1/USACE-NED (1989) general guidance.

U. . OVERALL CONCLUSION ON THE PROPOSED PROJECT

Based upon this review of the results of testing of the sediments proposed for dredging and dumping of dredged material from this project, the material meets the criteria for acceptability for ocean disposal as described in Sections 227.6 and 227.27 of the Ocean Dumping Regulations, and is suitable for unrestricted ocean disposal under US Environmental Protection Agency (USEPA) Region 1 /USACE-NED (1989) guidance.

Non-testing issues section

2. Review of Compliance

a. Purpose and summary: This memorandum addresses compliance with the criteria for evaluating permit applications under 40 CFR Section 227, subparts B, C, D and E, under the Ocean Dumping Act. Our review confirms that sufficient information was obtained to properly evaluate the suitability of this material for open water disposal and finds the sediments suitable for disposal as proposed.

b. Compliance with SUBPART B - ENVIRONMENTAL IMPACT

Section 227.5 Prohibited materials.

The material to be dumped is dredged material that has been evaluated and found to meet the criteria of the ocean dumping regulations. The material approved for disposal is not:

- high level radioactive waste;
- material used for radiological, chemical, or biological warfare;
- materials whose composition and properties have been insufficiently described to enable application of 40 CFR §227 Subpart B;
- inert synthetic or natural materials which may float or remain in suspension so as to materially interfere with fishing, navigation, or other use of the ocean;
- medical waste as prohibited by §102(a) of MPRSA.

Section 227.6 Constituents prohibited as other than trace amounts.

Section 227.7 Limits established for specific wastes or waste constituents.

§ 227.7(a) and (b): The proposed dredged material does not contain liquid waste or radioactive materials.

The proposed dredged material meets the requirements of §§ 227.7(c)(1) - (3) as discussed below.

Section 227.7(c) specifically applies to wastes containing living organisms, which in the case of dredged material potentially would consist of organisms dwelling on or in harbor sediments and pathogenic agents resulting from the presence of sewage treatment plants, combined sewer overflows (CSO's), surface run-off, inadequately treated boat discharges, and stormwater drainage systems. Under §227.7(c)(1) - (3), wastes containing living organisms may not be dumped if those organisms would endanger human health or the health of domestic animals, fish, shellfish, or wildlife by: (1) extending the range of biological pests, viruses, pathogenic microorganisms or other agents capable of infesting, infecting, or extensively and permanently altering the normal populations of organisms; (2) degrading uninfected areas; or (3) introducing viable species not indigenous to an area. As discussed below, disposal of the proposed dredged material at the Massachusetts Bay Disposal Site (MBDS) would not endanger human health or that of marine life or result in the effects specifically enumerated in §§227.7(c)(1) - (3).

The MBDS is located approximately 22 nautical miles (40.8 km) east-northeast of Boston with center coordinates of 42^0 25.100' N, 70^0 35.000' W. Physiographically, the site lies within the Stellwagen Basin, an elongated depression over 20 miles (32.2 km) in length which trends northwest-southeast. The site is situated in a 300-foot (91.5 meters)deep depression which is separated from the Stellwagen Bank area on the east by a 200-foot-(61 meters) high slope. The site is a circular area with a diameter of two nautical miles. The disposal site is therefore colder, darker, has greater water pressure than the proposed dredge site, and has a hostile environment for most of the organisms found at the proposed dredge site.

Pathogens are a greater problem at a local level rather than on a bay-wide level. Point and non point sources are considered to be the important contributors of pathogens at local level in Massachusetts (Menzie-Cura & Assoc., 1991, page x). Our review of the recent information on spills and point source discharges in the project's waterway gives us no reason to believe that the material to be dredged is seriously contaminated with pathogens.

Beach coliform bacteria standards (set by the state for protection of human health) are sometimes exceeded near the heavily populated areas of Massachusetts. It is likely that any coliform bacteria brought to the disposal site in sediment from these areas would not survive long enough in the cold, deep ocean water to be able to cause a problem.

With regard to potential introduction of viable species not indigenous to the area, the DAMOS monitoring studies for MBDS have not indicated the presence of non-indigenous species. The sediments to be dredged are from an estuarine area within the same faunal province as the disposal site. Furthermore, any organisms potentially in the material would have to survive the effects of dredging, transportation to the site by barge, and subsequent disposal. These factors make it highly unlikely that this dredged material disposal could introduce viable non-indigenous species to the MBDS.

In summary, the available evidence, including monitoring studies of the MBDS, indicates that dredged material is not a significant source of pathogenic contamination, that dredged material disposal will not extend the range of undesirable living organisms or pathogens or degrade uninfected areas, and that such disposal will not introduce viable non-indigenous species into the area.

§227.7(d) Requirements specific to wastes which are highly acidic or alkaline:

This subsection would be of greater relevance to liquid wastes or sludge. Dredged material is a naturally occurring substance derived as a result of weathering of upland rocks and soils, natural grain size sorting during transport, and deposition in a subaqueous environment. It is by nature composed of mineral grains that are not highly acidic or alkaline, but are at a near neutral pH, especially when formed in a salt-water environment such as the proposed project site. Thus, dredged material from this project is not highly acidic or alkaline.

§227.7(e) Oxygen consuming or biodegradable wastes.

Although large discharges of municipal and industrial waters from Massachusetts cause sporadic degradations of water quality by over-enrichment with nitrogen compounds, such as plankton blooms or reductions in dissolved oxygen, these impacts have not been linked with dredged material disposal activities. Rather, the dissolved oxygen concentrations observed in the water column, including in near-bottom waters, at the MBDS are saturated or near saturated, typical for this area of Massachusetts Bay (Hubbard et al, 1988, page 101). Furthermore, disposal would occur during the time when Massachusetts Bay is well mixed from the surface to the bottom, rather than in late summer when stratification creates conditions which could be conducive to hypoxia.

Wastes containing biodegradable constituents or constituents which consume oxygen in any fashion may be dumped in the ocean only under conditions in which the dissolved oxygen, after allowing for initial mixing, will not be depressed by more than 25 percent below prevailing conditions at the dumpsite at the time of disposal. Any dredged-material-induced DO reduction should be minimal and of short duration, as the dredged sediment has a relatively low organic carbon concentration and the disposal site is in open ocean with good water circulation.

Monitoring surveys at the MBDS Disposal Site give a depth average concentration, for all seasons, of dissolved oxygen of 9.5 ppm (mg/L) and a low value of 7.8 ppm during the summer season when low dissolved oxygen is common (Hubbard et al, 1988, page 101). A dissolved oxygen concentration above 6.0 ppm is thought to be protective of most marine life.

In summary, the chemical characteristics of high alkalinity and/or acidity, synergistic effects or formation of toxic compounds and depletion of dissolved oxygen in the overlying water after initial mixing would not be associated with the proposed project material.

<u>Section 227.8 Limitations on the Disposal Rates of Toxic Wastes;
Section 227.11 Containerized Wastes; and
Section 227.12 Insoluble Wastes:</u>

The material which is to be disposed does not consist of containerized wastes as defined in Section 227.11 nor does it violate the restriction on insoluble wastes as defined in Section 227.12. With respect to Section 227.8 (limitations on the disposal rates of toxic wastes), the proposed dredged material meets the criteria for acceptability based on the LPC as described in Section 227.27. Therefore, the proposed project material meets requirements outlined in Sections 227.8, 227.11, and 227.12.

Section 227.9 Limitation on Quantities of Waste Materials

Section 227.9 provides that substances that may cause damage to the ocean environment or seriously reduce amenities due to the quantities in which they are dumped may be dumped only when the quantities to be dumped at a single time and place are controlled to prevent long-term damage to the environment or amenities.

The total volume to be disposed from this project falls within the capacity of the MBDS. MBDS is estimated to have well in excess of a 50 year capacity based on the long-term average annual disposal volume of 233,000 cubic yards.

In addition, monitoring studies have shown the potential water quality impacts associated with the disposal event are likely to be short-lived. Longer-term water quality impacts are unlikely due to the stability of the dredged material on the floor of the disposal site (Hubbard et al, 1988, page 299, 313).

Therefore, the material proposed for disposal would not result in long-term damage to amenities or the environment due to the quantities to be dumped.

Section 227.10 Hazards to Fishing, Navigation, Shorelines, or Beaches

Section 227.10 provides that, with regard to the disposal of dredged material, the site and conditions must be such that there is no unacceptable interference with fishing or navigation and no unacceptable danger to shorelines or beaches resulting from dredged material disposal. The project material proposed for dumping at MBDS would not interfere with fishing, navigation, or pose unacceptable danger to shorelines or beaches as discussed below.

The Massachusetts Bay Disposal Site is located in an active commercial shipping and fishing area. The major commercial port is Boston. The MBDS is north of the shipping lanes used by the vessels going to and from Boston, thereby minimizing conflicts of use (Hubbard et al, 1988, page 285).

The ocean area surrounding MBDS is considered by NMFS to be a relatively productive fishing area. While disposal operations will disrupt commercial fishing activities and displace them from the area of the disposal site, MBDS should not have a significant adverse effect on the fishing industry of Massachusetts Bay (US EPA, 1989, page 209).

Recreational boating and fishing also take place in the Massachusetts Bay region. These activities are not located near the existing disposal site, and conflicts are avoidable. Recreational boating and fishing using small craft is usually concentrated in the more sheltered western portion of Massachusetts Bay. The larger craft which would utilize the eastern region are fewer in number and are better equipped to avoid disposal barge traffic.

A disposal mound of approximately 19.7 feet (6 meters) was measured at MBDS (DeAngelo & Murray, 1997, page 13); most mounds are smaller, e.g. 2.6 feet (0.8 meter) and 6.6 feet (2 meters) (USEPA Region 1/ USACE, 1996, page 23). The tops of disposal mounds at MBDS are 251.6 feet (79.69 meters) or deeper (DeAngelo & Murray, 1997, page 13). Having low disposal mounds at a deep-water disposal site avoids conflicts with commercial navigation. The MBDS is also noted on nautical charts and marked by a buoy.

There should be no unacceptable danger to shorelines or beaches resulting from dredged material disposal as the MBDS is more than 10 miles (16.1 km) away from any shoreline or beach, is deeper than 250 feet (76.2 meters) and has a depositional environment (USEPA Region 1/ USACE-NAE, 1996, page 12). Any material placed at MBDS can be expected to stay at MBDS and not affect any shoreline or beaches anywhere.

The proposed project material meets requirements in Section 227.10 in that the disposal of this material will not result in unacceptable interference with fishing or navigation or unacceptable danger to shorelines or beaches.

Section 227.13 Dredged materials.

The material proposed for dredging has been tested and meets the requirements of this section.

d. Compliance with SUBPART C: NEED FOR OCEAN DUMPING

Section 227.15 Factors Considered

Under Section 227.15, the need for this disposal is determined by: evaluation of the degree of treatment that is useful and feasible; whether the material could be reduced or eliminated by using other processes; the relative environmental risks, impact and cost for other alternatives; and any irreversible consequences of the use of alternatives.

Under Section 227.16, the need for this dumping is demonstrated when there are no practical improvements in processing or treatment to reduce the impacts of the waste, and there are no practical alternatives with less adverse environmental impact.

Because the material is predominantly composed of mineral components and water, a reduction in volume is impractical. To reduce the volume, land-based dewatering facilities would need to be located and constructed in addition to finding a landfill to dispose of the remaining volume. Contaminants in the sediments are present and determined to be at trace levels according to 40 CFR Section 227.6 as reported in the suitability determination, therefore treatment is likely to be very impractical and costly (even when contaminants are present in higher concentrations, their treatment can often be impractical and costly). Other alternatives could also have different and greater environmental impacts such as those associated with construction of staging areas, road transportation impacts (additional truck traffic and air emissions), and construction or use of alternative placement sites. There are no practical alternatives, as determined in suitability determination. Therefore, the proposed dredged material disposal meets both of these requirements, and there is a need for this disposal.

e. Compliance with SUBPART D: IMPACT OF THE PROPOSED DUMPING ON ESTHETIC, RECREATIONAL AND ECONOMIC VALUES

Subpart D sets forth the factors to be considered when evaluating the impact of proposed dumping on esthetic, recreational, and economic values, including the potential for affecting recreational and commercial uses and values of living marine resources.

The factors specifically considered include recreation and commercial uses, water quality, the nature and extent of disposal operations, visible characteristics of the material to be disposed, presence of pathogens, toxic chemicals, bioaccumulatable chemicals, or any other constituent which can affect living marine resources of recreational or commercial value. These would be used in an overall assessment of the effects of the proposed dumping on aesthetic, recreational, or economic values.

All of these considerations have been discussed under Subpart B, above, with the exception of visible characteristics of the material and the consequences of <u>not</u> authorizing the disposal.

The material from this project, as is typical of dredged material, is composed of wet sediments that have accumulated on the bottom of the area to be dredged and, when disposed, will quickly sink to the bottom, leaving no visible plume shortly after disposal. On the basis of this and the discussions in Subpart B above, it is determined that adverse impacts to the visual esthetics would not occur as a result of the disposal.

With respect to the consequences of not authorizing the dumping, if the dumping were not authorized there would be an adverse economic impact on those businesses relying on these channels and/or berthing areas.] Failure to dredge this project would also significantly adversely impact recreational boating, and associated esthetic values. Surveys of the project area indicate that numerous areas within the proposed dredging areas have shoaled. Maintenance dredging is needed to return the project to authorized dimensions if the present commercial and recreational uses of the project are to continue. Shoaling restricts available depths, which, if not maintained, would continue to shoal, posing hazards to navigation.

Related marine services account for the largest part of total revenues while providing both full and part time employment to the local populace.]

f. Compliance with SUBPART E: IMPACT OF THE PROPOSED DUMPING ON OTHER USES OF THE OCEAN

Subpart E sets forth the factors to be considered in evaluating the impacts of the proposed dumping on other uses of the ocean, including long-range impacts. Specifically, the uses considered include, but are not limited to, commercial and recreational fishing in open ocean areas, coastal areas, and estuarine areas; recreation and commercial navigation; actual or anticipated exploitation of living and non-living marine resources; and scientific research and study. An overall assessment of the proposed dumping on the temporary and long-range effects of other uses of the ocean would include irreversible or irretrievable commitment of resources that would result from the proposed dumping.

As was discussed in section III, 6 above in this memorandum, commercial and recreational fishing and navigation would not be adversely affected by this disposal. If the disposal site were abandoned, the fishing use of this area could be re-established, as the DAMOS studies show that the disposed sediment mounds are quickly colonized by marine organisms. Furthermore, past dredged material disposal at the MBDS has not affected the ongoing study, use, and enhancement of Massachusetts Bay.

Therefore, based upon the discussions in this memorandum and the suitability determination, and in consideration of Hubbard et al (1989), the proposed dredged material meets the requirements of this section that there will be no adverse impact on the other uses of the ocean.

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